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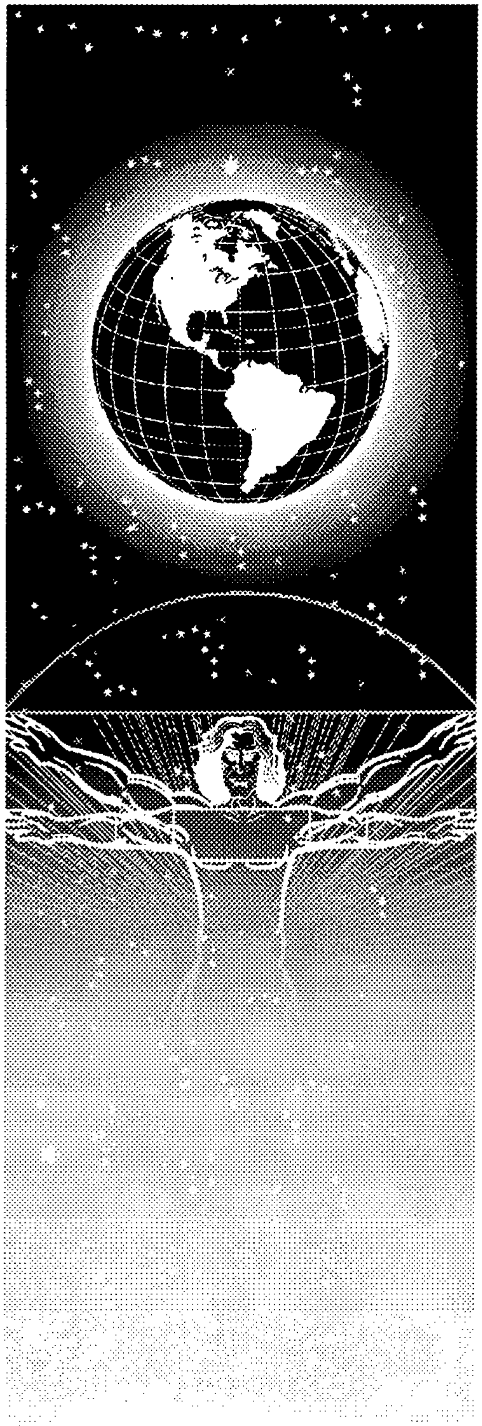

UNITED STATES AIR FORCE ARMSTRONG LABORATORY

Overcoming Groupthink Bias with Groupware

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This paper has been reviewed and is approved for publication.

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PREFACE

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13. ABSTRACT *(Maximum 200 words)*

Four-person groups simulated a procurement decision implemented as a "hidden profile" problem. Some of the information relevant to the decision was provided to all members of the group, while other information was provided only to infividual group members. A 2 x 2 factorial design was used to study group decision making quality. Groups either had individual preparation time before the meeting or they did not. In addition, groups either used an electronic voting tool to tally their votes or they did not. A separate control group was also used in which all members had all the information needed for a correct decision. The predicted interaction between computer-aiding and group task structure was confirmed. Groups that did not use computers and had individual preparation time before the group meeting usually failed to solve the problem correctly. Computer aiding (i.e., the electronic volting display) approached but did not reach statistical significance. The results point to a need to marry specific types of group support technology not just with specific group problem solving needs, but tith specific task procedures tailored to the group context.

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SUMMARY

This experiment examined whether a computer-based group voting tool would improve group decision making on a hidden profile problem. Hidden profile tasks require group members to combine unshared information (i.e., information held by some group members but not all) to make a correct decision. Stasser and his associates have found that there is a strong tendency for groups to discuss shared information (i.e., information held by all group members) and to ignore unshared information when working on group problems.

In this experiment, the hidden profile was constructed to create a group bias favoring one of three fictional companies who were competing to win a contract. An electronic voting tool which combined and displayed information from individual group members on a group screen was used. The experiment was a 2 x 2 between subjects factorial design with a control group. Four-person groups either used or did not use this group support tool, and they either did or did not have individual work time before the group decision meeting. Groups not using computer aids to work the problem were given a preliminary training task illustrating the method of entering data into a matrix on a laptop screen. They also had the same information matrix on paper as the computer-aided groups had on the laptop display. Every member of the control group had all the information about the three companies.

The predicted interaction between computer-aiding and group task structure was confirmed. Groups that did not use computers and had individual work time before the group meeting usually failed to solve the problem correctly. Computer-aiding alone approached but did not reach statistical significance. The results point to a need to marry specific types of group support technology not just with specific group problem solving needs, but with specific task procedures tailored to the group context.

INTRODUCTION

It is a curious fact that when group members have unique information they often do not share it in meetings. Stasser and associates (Stasser & Titus, 1985; Stasser & Stewart, 1992) have found that laboratory groups tend to focus on information they hold in common rather than the unique information each may have. Using a hidden profile method, they found that even when unshared information was brought forth it did not necessarily alter the group decisions. The failure of groups to pool their information effectively can restrict the range of options that groups explore and lead to poor decisions.

This phenomenon is related to another fact of group life known as groupthink (Janis, 1972, 1982). Groupthink occurs when decision makers settle prematurely on a limited set of options owing to pressures of time, task complexity, conformity, and other factors. As Stasser found with information pooling in small problem solving groups, Janis observed that people in deliberating groups tend to show interest in ideas that support their initial or preferred option, and ignore contrary options. Often, better choices are available to the group, but they are not considered once the groupthink mentality has been established. Groupthink is especially prevalent when group norms stress cooperation and consensus building.

These examples of negative group outcomes stand in ironic contrast to the usual purposes of groups in everyday decision making. Among other things, we value group discussion as a way of surfacing relevant information and examining feasible solutions to problems by pooling cognitive resources. The fundamental rationale for a group approach to decision making can be found in the adage that two (or more) heads are better than one. By bringing different perspectives and sources of expertise to bear on a problem, it seems reasonable to expect a better solution to emerge with groups rather than with individuals acting alone.

There is an increasing emphasis on teams and other work sharing groups in modern organizational life. Getting more value from coordinated team efforts is a central theme of total quality management, and everywhere there is a push for increasing the productivity from workers for competitive advantage. Hence, it is becoming economically important for many organizations to know how group work can be made more productive. In Steiner's (1972) terms, can we devise techniques to mitigate process losses and stimulate process gains from group work? These questions about the meaning and manner of aiding group

work now have more than academic interest; they have practical economic consequences for many organizations.

A new array of computer technologies is emerging which, its advocates believe, can significantly improve organizational team work. These technologies go by several different names, but they are often lumped together under the term groupware. The terms group decision support systems, group communication support systems, and group support technology, are also applied to such tools. Group support technologies are beginning to find a broad commercial market (e.g., Ellis, Gibbs, & Rain, 1991), and they underlie a new research discipline called computer-supported cooperative work (e.g., Association for Computing Machinery, 1992).

In general, group support technology uses computer software and networking tools to help work groups communicate and collaborate on joint tasks more effectively. Often, these tools provide direct support for commonplace group needs in face-to-face meetings. They are sometimes embedded in networked computer workstations in "high tech" conference room facilities. Computer workstations for such purposes include communication software for idea generation, file sharing, messaging, voting, problem analysis, document editing, and other group activities. A human facilitator is often required in such situations. Computer support for "distributed" groups collaborating in different places and/or different times is also emerging. Electronic mail and network bulletin boards are examples of this rapidly expanding group technology format.

Like the literature on small group behavior which came before it, the empirical literature on the effects of this new group support technology is already large and diverse. Some attempts to summarize and integrate this body of research into dependable findings and principles have been made (e.g., Pinsonneault and Kraemer, 1990) and conceptual frameworks for linking group processes with computer support tools have been proposed (e.g., Dennis, Nunamaker, & Vogel, 1991). Surely one of the reasons for the equivocal pattern of research findings is that many of the published studies on group support technology are methodologically weak (McGrath & Hollingshead, 1993). Two examples illustrate the problem. First, it is common in this literature for experimental studies not to have control groups. Computer-supported groups are not compared on a common yardstick with what might be called "manual" reference groups. This makes bench marking problematic. Second, most studies do not consider the role of human facilitation as a unique source of variation in computer-supported group results. Experimenter bias

(Rosenthal, 1966) is a well documented phenomenon of the experimental social science literature. It may account for some of the contradictory findings in the literature since human facilitation is frequently used in empirical studies. In such circumstances it is small wonder that the experimental knowledge base for group support technology is so inconclusive on key points.

In their review of the group support technology literature, McGrath and Hollingshead (1993) argue for a more explicit examination of features of the group, features of the task, and features of the situation in which the group operates. To them, the important question is not whether computer-aiding helps groups in general. Instead, they advocate a research strategy than can relate specific types of groups and tasks to specific group work technologies. To have theoretical and applied value, research should try to separate these group, task, and technology effects. McGrath had earlier proposed a "task circumplex" identifying four task performance processes (generate, choose, execute, and negotiate) and eight task types (creative, planning, performance or psychomotor, competitive, cognitive conflict, decision making, and intellective). This rubric (McGrath, 1984) seems to have been adopted by many of the leading researchers in the groupware field.

The present study attempted to relate performance on one kind of group task (an intellective task) with one type of group support technology (a simple electronic voting and display technique) in one type of group situation (induced groupthink bias). We adapted the hidden profile technique used by Stasser to provide continuity with a relevant and flexible paradigm for studying group decision making. We implemented rigorous experimental procedures and controls to minimize threats to internal and external validity. The experimental task we created was a simulated purchase decision made by a small group of "procurement executives." Although fictionalized, this type of task replicates many of the features of decision problems faced by real-world groups. As well, the voting support tool we devised mimics the the essential characteristics of real groupware tools.

Experimental Rationale and Hypotheses

We posited that software voting tools implemented on individual group members' computer and combined into a group data display would elucidate the hidden profile. That is, groups would make better decisions with this kind of tool in this kind of problem. Other things being equal, groups should be more likely to identify the correct solution to hidden

profile problems when relevant information is collected electronically from each group member separately, and then combined in a display viewed by all before discussion begins. In short, we viewed this type of group support as both an antidote to group decision bias as well as a device for efficient information sharing within the group.

From Janis' writings (1972, 1982) we also posited the mitigating effect of independent preparation time prior to the decision meeting on the operation of groupthink. Janis mentioned having group members prepare for the meeting independently and recording their ideas to negate premature consensus bias, or groupthink. In the context of group support systems research, Nunamaker et al. (1993) might class this pre-meeting preparation as serving process and task support roles. Process support includes the communication media used by the group. Group support technology allows anonymous and parallel communication through keyboard entry of ideas from individual keyboards into the common viewing area. It also promotes group memory by eliminating air time and production blocking problems and by capturing all inputs by group members.

Individual preparation time before group decision meetings should lead to more information being shared and promote process gains through more objective evaluation and reducing group errors. Nunamaker et al. (1993) point out that effective process support and task structure need not always come in electronic forms. That is, at least some of the benefits of process support can be obtained from conventional, "low tech" methods. For example, long before electronic meeting support technology became available, Van de Ven & Delbecq (1974) showed that brainstorming groups were more effective when members had been allowed time for individual work and thought beforehand. By including individual preparation time as a factor in this experiment, we wanted to examine its synergistic effects with group support technology.

The consolidation of ideas through individual worktime should have several effects. In this experiment, it should allow subjects to better recall what they had just studied in the hidden profile problem statement. It should convince subjects of the correctness of their initial impressions and encourage them to withstand persuasion by other subjects with different positions. In a groupthink situation, such resistance to persuasion would be beneficial. But in the general hidden profile situation it would be detrimental because the group composite view of the problem is actually better than individual views.

First, we hypothesized that the condition in which subjects had individual work time before the group meeting, but did not have use of computers, would produce fewer correct decisions than the condition in which subjects had individual work time plus the use of computers. The computer display of the group's combined information should overcome individual group members' initial convictions about the best choice. In sum, we hypothesized an interaction between computer aiding and process/task support.

Second, we hypothesized that members of groups who were not given individual work time should be more open to group persuasion; that is, they would be less adamant or confident of their pre-meeting positions. Since all groups were given instructions meant to avert the tendency to overemphasize the shared information, the groups with no individual work time should adopt the group composite view of the problem and produce more correct decisions than those who had individual preparation time. In sum, we hypothesized a main effect for process/task support in the form of individual preparation time before the group meeting.

Third, we hypothesized that the control condition, in which each group member had all information relevant to the group problem, would produce more correct decisions than the other four experimental conditions.

Fourth, we hypothesized that group decisions would take less time for groups using computer support than for groups not using computer support.

Fifth, we hypothesized that groups using computer support would feel more confident in their decisions than groups not using computer support.

METHOD

Subjects

The subjects were 192 paid volunteers. Most were undergraduates. Subjects participated in groups of four assembled from sign-up sheets posted around the university campus. We made no attempt to match the composition of these groups for sex, age, or familiarity with each other or
with personal computers. All subjects signed an informed consent sheet before participating.
The procedure adhered to published ethical standards for human use of human subjects.

Experimental Design

The experiment was a 2 x 2 between-subjects factorial design with one control group. Four-person groups either used or did not use a computer aid to develop a group decision on a hidden profile problem, and they worked or did not work individually before the group decision meeting. A fifth experimental group was used to benchmark performance under control conditions. Each person in this group had the true (i.e., complete) profile of the problem to work with, and no computer support was provided.

Group Problem

We used a hidden profile method to study group decision making under the five experimental conditions. In this experiment, subjects role played a group of acquisition executives whose task was to rank proposals to build a new air/ground intelligence gathering system. The system was represented to the subjects as imaginary. Proposals from these companies were provided to the subjects in one-page capsule summaries. The proposal summaries were supposed to address ten pre-defined selection criteria. The group was instructed to rank the proposals according to the number of criteria each one met, giving equal weight to each, and considering no others. This was an intellective task with an objectively right answer. There was no ambiguity about whether selection criteria were met, and the proposal summaries contained no contradictions. The three companies were named Franklin, Starlight, and Cape.

The information in the hidden profile was manipulated to create a group bias favoring Franklin by distributing information about each proposal differently for each subject. All subjects saw five favorable criteria for Franklin (i.e., shared information). But four other negative pieces of information about the Franklin proposal were disclosed singly to one or two of the group members (i.e., unshared information). The true profile for Franklin was five positive and five negative. Because the negative information was not given to the whole group but only to individual members, the Franklin proposal was made to look better to individual group members than it actually was. In fact, Franklin was the worst proposal.

Starlight was the best proposal. We shared the two negative pieces of information about Starlight. But we dispersed eight items of positive information about Starlight within the group. With two negative and two positive pieces of information, Starlight should appear to be a mediocre proposal from the viewpoint of individual subjects. Cape's proposal was described in a mixed pattern. No information was fully shared, and the mix of positive and negative points was about equal for each subject. Cape's true profile was six positive and four negative.

Table 1. Information Distribution in the Hidden Profile

	Starlight				Franklin				Cape			
Criterion	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Fits on 2-ton truck	N	N	N	N		N			Y			
Sweep sensor field in 30 minutes			Y				N		N	N		N
Recover/relaunch in 90 minutes	N	N	N	N				N	Y	Y		Y
Can process at 100 MIPS		Y			Y	Y	Y	Y	Y	Y		Y
Computer smaller than 40 cu. in.				Y	Y	Y	Y	Y	Y		Y	
Computer weighs less than 10 lbs.				Y	Y	Y	Y	Y	N	N	N	
Computer 1000 hours before failure		Y			Y	Y	Y	Y	N		N	N
Costs less than $7 million	Y				Y	Y	Y	Y				
Past performance OK	Y				N	N	N	N		Y	Y	Y
Manufacturing capacity exists			Y					N				Y
True Profile	8+/2-				5+/5-				6+/4-			

Information Distribution. Table 1 shows the patterns of shared and unshared information and for positive and negative information about the three competing companies. The procedure required the subjects to read and memorize three proposal summaries, each containing between four and seven pieces of relevant information. For example, regarding Starlight, Subject 1 (S1) saw two negative and two positive pieces of information. S2 saw the same two negative pieces of information but two different pieces of positive information, and so on for S3 and S4. In short, the bad news about Starlight was known to all; the good news was known only to individuals, and each had a unique slant on the news. To rank Starlight first (i.e., to make the objectively correct decision) the groups had to assemble this unshared good news in the face of shared bad news. At the same time, the groups had to overcome a manipulated bias in favor of Franklin. Note in Table 1 that all of the positive points about Franklin were known to all, but four of its five negative points were known by only one person in the group. Note also the appearance of Cape as a mixed picture of positive and negative points. The evidence for all three companies as seen from the viewpoint of single group members creates a pre-meeting bias favoring Franklin. To check this manipulation, we asked subjects to rank the proposals after private study but before going into the group meeting. Nearly all subjects chose Franklin, the groupthink solution, as the best proposal.

Pilot Testing. In pilot testing, the proposal summaries also contained irrelevant facts about the companies. This was intended to disguise the fact that the relevant information provided to each subject was incomplete. Appendix B contains these summaries. After studying the proposal summaries in private for 20 minutes, the subjects convened for a group discussion to arrive at a joint ranking. Most of the 15 pilot groups chose the groupthink solution (i.e., Franklin) regardless of experimental condition. Subject debriefing led us to believe that the task was too demanding on short term memory. We made the task less difficult by omitting the distractor items. This change in format also forced group discussion to focus only on relevant facts. We noticed that pilot groups tended to discuss both relevant and irrelevant facts despite intructions to decide only on the facts related to the ten evaluation criteria. At the same time, we ran 11 groups in the fully shared control condition to determine the optimal ratio of shared/unshared information. We found that when all subjects were given the true profile about the companies (i.e., all ten pieces of information about each company) the groups invariably ranked the companies in the correct order.

Computer Aiding

Computer aiding for this experiment had two simple features. In the two computer-aided groups, laptop computers were used to record information about the three proposals. Individual subjects saw a matrix on the laptop screen with the ten evaluation criteria in the rows and the three companies in the columns. We told the subjects to enter a "Y" if the criterion was met, a "N" if it was not met. We also told the subjects to withhold a vote if they were not sure, or if the criterion was not addressed in the proposal summary. Second, the data inputs from individuals were combined via local-area network software into a group display of the voting results. This group display was projected on a 3 ft. x 4 ft. section of the wall in the observation room. The group display used the same row (criteria) and column (company) format as the individual input matrices, but it also had a bar graph. The bar graph showed the combined results of the individual voting. The higher the bar graph, the greater the number of criteria the company had met. We told the groups to use this bar graph display as a jumping off point for group decision making. If all subjects in the computer-aided/individual work condition recalled and entered their information correctly, the bar graph would start the group off with the correct answer already in plain view. We expected that these groups would develop a group decision that affirmed this initial result. Figure 1 shows what this display would look like with correct information. (i.e, the true profile) for each company.

Criterion

Fits on 2-ton truck
Sweep sensor field in 30 minutes
Recover/relaunch in 90 minutes
Can process at 100 MIPS
Computer smaller than 40 cu. in.
Computer weighs less than 10 lbs.
Computer 1000 hours before failure
Costs less than $7 million
Past performance OK
Manufacturing capacity exists

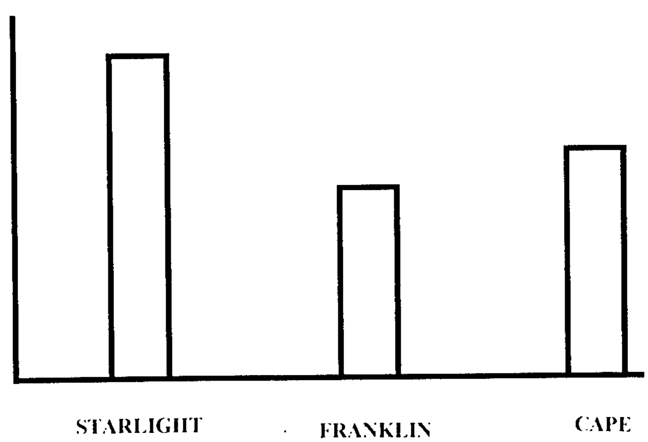

Figure 1. Bar Graph Group Data Display

Subjects did not have to type; they only had to position the cursor over the desired cell of the 10 (rows listing criteria) x 3 (columns listing companies) matrix and press "Y" or

"N" and "Enter" when done. They were instructed to skip over cells that did not apply. As Table 1 shows, the number of items to be recalled and entered into the matrix for each company by each subject was four and seven.

Procedure

Overview. Subjects participated in the experiment in groups of four. Each subject was asked to assume the role of a procurement executive charged with evaluating three proposals with three other executives. These proposals were to be evaluated on ten criteria. The criteria were to be equally weighted; that is, each was worth ten percent. The subjects were told to rank the proposals according to the number of criteria they met. All subjects worked a sample problem on the laptop computers to familiarize themselves with the basic format for data entry and group data display. Subjects were then separated and studied information booklets for twenty minutes. In addition to the three proposal summaries, the information booklets contained a brief description of the new system to be developed and the ten evaluation criteria. (Appendix A) During this study period, subjects were not allowed to talk with one another. Instead, they were to carefully study the proposal summaries and memorize as many of the facts as they could. Before reconvening in the observation room for discussion, subjects made an initial ranking of the three companies as a manipulation check. Each group discussed the task until they had a group ranking of the three companies. They wrote this ranking on a sheet of paper and handed it to the experimenter after calling him back into the room.

Subjects were introduced, given name tags, and read and signed informed consent forms. The experiment was introduced: "This study is on group decision making. Please give your full attention to all of the study. I will be escorting you back and forth between this room and the observation room a few times during the study. Please use the same seat each time in each room. The group will be videotaped during the decision making session. You will be paid $10 for your full participation at the end of the study. The study will take about an hour to complete. Please do not rush."

All groups were taken into the observation room to work the sample problem as a training exercise. Subjects were seated around a conference table with Intel 486 laptop computers equipped with network cards in front of each. The sample problem had the same structure as the experimental task. The computer procedures were also the same. "You are asked to decide about buying a new car. One way you might approach the task would be by

using the set of criteria you see on your screen. You could rate whether each model of car meets your standards or not and leave the criterion blank if you don't know. Please rate the cars on the criteria now with a yes (Y), no (N), or abstain (A). Make sure the cursor is where you want before you enter your answers. If you want to change a decision, move the cursor to the spot and type the response desired (Y, N, or A) and it will change. Please read the sheet and enter your choices now. I will come around to see that you have the responses you want."

The computer screen displayed a 3 (criteria) x 3 (cars) matrix. Each subject received only one piece of information (cost, safety, or performance) about each of the three candidate cars. Each subject entered his or her information in the computer matrix. The experimenter used a fifth laptop computer, acting as a server, to combine the information for group display through a color projector on the observation room's wall. This display was about 4 ft. wide and 5 ft. long, projected 6 to 8 ft. from the subjects seated at the table.

"This computer system summarizes the information from individuals in order to help groups make better decisions. Before I show you the group results, I want to make some points about the display. A red "x" for a particular car and criterion means that at least one of you has voted that that car meets that particular criterion. So the number of red "x's" under a particular car tells how many criteria it has met. Also, the vertical green bars under each proposed solution or car indicates the overall performance for each car. The taller the bar, the better the car. "

When the whole group's information was combined on the large screen, it was apparent in the bar graphs that one car met two criteria and that the other two cars only met one criterion each. The decision should be to purchase the car that met the most criteria. The experimenter ascertained that each group got the right answer and that all subjects understood the mechanics of entering data using the laptop computers.

After the car example was completed, subjects were escorted to the outer room and the main task was presented: "This study is to examine how and how well groups make decisions. There is a correct answer to this decision making task and you should keep this in mind as you are preparing for it. You will have 20 minutes to study the notebooks and make notes. You will not be able to bring the notes or the booklets into the observation room with you. I recommend that each of you organize the information in your notes the first 15 minutes. Then you should try to memorize the information the last 5 minutes. It is

important to remember which specific criteria in the booklet are met by each company. You may have unique information, so you are the expert on that information. However, none of you have information that is contradictory to anyone else's."

After the 20-minute study time, the experimenter collected the matrix forms and the booklets and escorted the subjects to seats around a conference table in the observation room. At this time the groups received different instructions according to the experimental condition the group was in. The four sets of instructions follow.

Computer Aiding/No Individual Work

"You will notice that your computer screen has a matrix with the criteria and the companies on it for your use. You may begin group discussion and decision making now. You may talk and work together to put the information into the computers as you are discussing it." The experimenter explained how to enter their responses again: "To combine the information on the front screen, you may knock on the door and I will enter it on the screen for you." If anyone asked what they were supposed to do, the experimenter restated "You may begin group discussion and decision making now."

Computer Aiding/Individual Work

"You will notice that your computer screen has a matrix with the criteria and companies on it for your use. Work individually and record information without talking." The experimenter explained how to enter their responses again. "When everyone has the information in as they want it, knock on the door and I will come back in at that time. Then you may begin group discussion and decision making after that individual work time. Please do not discuss the problem until I return. Are there any questions?"

No Computer Aiding/Individual Work

"You may begin group discussion and decision making now. You may talk and work together to arrive at a group decision. Work until you have a group ranking of the companies. When you have your group ranking, knock on the door to get me." If anyone asked what they were supposed to do, the experimenter restated "You may begin group discussion and decision making now." The experimenter distributed a copy of the loose

booklet sheet and a blank scratch sheet to each subject and said "Here is a copy of the loose sheet from the booklet and a scratch sheet for you to use."

No Computer Aiding/Individual Work

"Work individually to record information without talking. When everyone has the information recalled and written as they want it, knock on that door and I will come back in the room. Then you may begin group discussion and decision making after that individual work time. Please do not discuss the problem until I return. Are there any questions?" The experimenter then distributed copies of the loose sheet and a blank scratch sheet to each subject and said "Here is a copy of the loose sheet from the booklet and a scratch sheet for you to use."

The control condition was exactly like the No Computer Aiding/No Individual Work condition except that all group members had all the information.

Each of the five groups worked on the task according to the instructions they received. Apart from these instructions, groups were free to conduct their meeting in any fashion they chose. There was no time limit to reach a decision. The experimenter left the room during the group meeting. There was no human facilitation.

We videotaped all group meetings to capture decision time and individual participation rates. After recording their group consensus rankings, each group member was escorted outside the observation room to an individual workstation to record supplementary ratings. Each subject gave his or her private ranking of the proposals to show individual divergence from the group concensus decision. In addition, subjects rated their confidence in the group decision.

RESULTS

We compared the correctness of the group decisions in two ways. First, we created a five-point scale in which the higher the score, the better the match between the group decision and the correct solution according to the true profile of the three proposals. A score of 5 was assigned to the correct ranking (i.e., three proposals each ranked in correct position) and a score of 1 to the most incorrect ranking (i.e., three proposals each in incorrect position). Table 2

Table 2. Group Ranking Scores (Range Worst to Best = 1 to 5)

	N	Mean
Computer Aid/Individual Work	8	3.875
Computer Aid/No Individual Work	9	3.444
No Computer Aid/Individual Work	9	1.889
No Computer Aid/No Individual Work	11	3.818
Control	11	4.545

shows the mean scores for each of the five conditions and the number of four-person groups (N) per condition. We analyzed data for 48 groups in all. A one-way analysis of variance performed on the mean scores for each of the five conditions showed a significant overall difference ($F = 4.68$, $p. = .0002$). The Tukey HSD test on pairwise mean differences showed that the No Computer Aid/Individual Work condition did worse than all other conditions except the Computer Aid/No Individual Work condition. An ANOVA using only the four experimental conditions was also significant ($F = 4.68$, $p.= .0078$). The Tukey HSD pairwise comparison of means showed the same pattern. A 2 x 2 ANOVA showed the following:

C.A. (Computer Aid) Main Effect	$F(1,33) = 3.52$, $p. = .069$
I.W. (Individual Work) Main Effect	$F(1,33) = 3.04$, $p. = .090$
C.A. x I.W. Interaction	$F(1,33) = 7.54$, $p. = .010$

The second way we analyzed the correctness of the group decision was to simply classify groups according to whether the proposal ranked first was correct. In other words, we recorded the number of groups choosing Starlight in the first position, ignoring the correctness of the other two rankings. The results are shown in Table 3. Again, analysis using this scoring method as the dependent variable showed that the No Computer Aid/Individual Work condition did worse than the others (chi square = 18.01, $p. = .0012$). Likewise, an analysis omitting the control condition showed a significant difference. The Fisher Exact Test showed that the Computer Aid vs. No Computer Aid difference was significant at the Individual Work condition ($p. = .015$) but not at the No Individual Work condition. We expected that the control condition with shared information would always give the correct first rank.

Table 3. Groups Ranking Starlight First (0% shared positive information)

	First	Not First
Computer Aid/Individual Work	7	1
Computer Aid/No Individual Work	7	2
No Computer Aid/Individual Work	2	7
No Computer Aid/No Individual Work	9	2
Control	11	0

Decision Time

We compared the time needed to arrive at a group decision in each of the five conditions by computing group means from video recordings of invididual decision meetings. Results are shown in Table 4. ANOVA across all five groups was significant, $F(4,42) = 5.73$, $p = .004$.

Table 4. Decision Time in Minutes

	Mean
Computer Aid/Individual Work	8.35
Computer Aid/No Individual Work	8.41
No Computer Aid/Individual Work	10.83
No Computer Aid/No Individual Work	16.31
Control Group	7.06

When decision time was examined in a 2 x 2 ANOVA, only the difference between Computer Aid vs. No Computer Aid was significant, $F(1,32) = 6.30$, $p = .017$. The computer groups reached decisions faster than unaided groups.

Decision Confidence

One-way ANOVA, $F(4, 191) = 2.33$, $p. = .057$, showed that the control condition, in which all group members had full information, tended to have greater confidence in the correctness of the group decision. The No Computer/Individual Work condition produced the least confidence in the group decision.

DISCUSSION

The results confirmed the primary experimental hypothesis. By themselves, neither computer aiding nor task structuring of individual work led to significantly better

performance in this group decision making context. In general, except for the No Computer Aid / Individual Work condition, all experimental groups performed well on both versions of the decision quality measure. Although each person started with a bias toward one of the alternatives (an inferior one) the groups were able to reach the correct choice most of the time. The differences between groups reflect relative performance, not absolute performance. From this perspective, group decisions were better with computer aiding, but not significantly so. And individual preparation time by itself had no significant effect on group performance. That is, the two main effects did not explain the variance in relative group performance. However, there was a significant and persistent interaction between computer support and task structure here. By both measures of group performance, decision quality was strikingly poor when individual work time was not paired with computer-aided information capture. In sum, groups in this experiment needed both computer aiding *and* a structured task procedure to overcome the manipulated pre-meeting bias.

The findings are generally consistent with Stasser's work using the hidden profile paradigm for studying group decision making. By eliminating extraneous information from the group decision situation, we made it more likely that the hidden profile would be revealed for groups in each condition. Like Stasser & Stewart (1992), we told the groups that there was a right answer to the problem, and like Stewart & Stasser (1993), we told group members that they were "experts" on certain subtopics (that is, each person had unique information). In general, it appears that such instructions lead to more correct decisions in groups working hidden profile problems with or without computer support.

But the results here point to an important exception to this general rule. The quality of group decisions can be seriously degraded if the decision aiding technique is not well matched to group working style. Although computer-aided groups tended to do better in this experiment than non-computer groups, they did not do significantly better. Statistically significant variance in group performance is shown only in the interaction between computer aiding and group work structure. In line with our hypothesis, groups whose members recorded their information by themselves and without the computer aid fared very poorly compared to other groups. It seems likely that individual work time in this groupthink context only served to reinforce individual member's biases before the group meeting. A review of the videotapes of the group meeting for this condition showed conversation focused only on the shared information, not the unshared information. Even in instances where unshared information was brought up, its implications were not assessed by

the group. This also is consistent with Stasser's general findings about the pooling of unshared information during group discussion (Stasser, 1992). Groups focus on information they hold in common. Unique or unshared information, even if it is brought forth, will not necessarily change the direction of group deliberation or lead to a different group consensus.

Although the main effect for computer aiding was not significant by conventional standards (p. = .06), the result seems consistent with the general pattern of group behavior described as "mindguard" by Janis (1982). Decision making groups tend to consider only a limited number of options when there is pressure to reach agreement, and tend to ignore options that contradict the prevailing group view. The classic groupthink phenomenon was observed in all experimental groups here. The electronic voting tool we used clearly helped to get relevant information into the discussion that would otherwise have remained submerged. And even though it was a very simple and limited technology intervention, the group display of the relevant facts before the discussion helped our groups to make the correct decision most of the time.

Group support technology usually includes an array of meeting support tools such as electronic brainstorming, messaging, idea analysis, report writing, and voting, among others. It is important to note that we used only a voting tool here. The group display of voting results was visible on both the individual computer screens and the observation room wall during the meeting, but subjects did not vote during the meeting. The computer aid was used just before, but not during the group meeting. It was used only as a device for getting relevant information into the discussion, not as a medium of communication during the discussion. As well, unlike most group support systems, the decision meetings here were not facilitated in any way. These choices about method gave us a high degree of experimental control, but they also introduced a degree of artificiality. We know that our findings are free of experimenter effects, but we also know that voting tools like ours might not be used in the same way in real world decision making meetings.

The experimental procedure was artificial in another way, too. We restricted group support technology to only one tool, electronic voting and tallying. We might have used voting in conjunction with electronic brainstorming or other software devices commonly found in group support tool kits. With such a limited range of electronic support for group meetings, our findings suggest little about the value of group support technology as a whole. They say something about the value of one kind of group support technology --

voting -- in one kind of group decision situation -- groupthink bias. Nevertheless, the value of such electronic aids in the wider context of group meeting support seems plain. And groupthink bias is not just a laboratory phenonenon. It is a common problem of group life that might be averted with computer-based tools and group procedures tailored to this purpose.

Groupthink bias can be classed with production blocking, conformity pressure, information overload, and underuse of information as sources of group process losses. These process losses interact to produce suboptimal results from group work (Steiner, 1972). Group support technology has been proposed as a way to mitigate or prevent these process losses (Nunamaker et. al., 1993). For example, anonymous and parallel communication, the hallmarks of computer-aided brainstorming tools, are thought to act as antidotes to process losses from traditional brainstorming methods. Air time and production blocking have been problems with idea generation in groups, especially with groups larger than ten.

At the same time, computer-aiding of group communication in meetings may also lead to process gains. Group work with computer support may yield greater synergy, learning, and information than unaided group work for many types of group tasks (Nunamaker et al. 1993). We have also seen in this experiment that group consensus may require less time and effort when electronic task support is used. This speeding of group work may or may not be a good thing. If groups move too quickly down the wrong path, it might be more useful for group support technology to slow them down.

Nunamaker et al. (1993) describe four theoretical mechanisms through which computer aiding of group work might affect the balance of process gains and losses. They call these *process support* (the means and manner of communication), *process structure* (the techniques or rules that control the timing and content of communication), *task support* (the computational tools), and *task structure* (techniques or rules for analyzing task information). This experiment made use of task support and task structure and showed how they might interact. The data input matrix used to tally individual results and create the group display of voting is an example of task support. Having the individual members work first by themelves vs. laissez faire group meetings is an example of task structure. Nunamaker et al. (1993) describe task structure as improving group performance by reducing losses owing to incomplete information sampling, avoiding or catching errors, and focusing on objective evaluation. Our findings suggest that the type of group problem and the psychological atmosphere of the group also need to be considered in a complete

taxonomy of groupware's effects. In particular, Steiner's "intellective" may benefit from technology and procedural interventions used in appropriate combinations. In the current experiment, an networked electronic voting/polling device represented one element of technology support from groupware. Procedural support for the group, usually supplied by human facilitation, was not supplied here.

The findings support an outlook on group research advocated by McGrath and Hollingshead (1993). They describe how work group behavior is altered by computer and communication technology. Since workgroup computing in the form of electronic mail, desk top videoconferencing, and the Internet is becoming commonplace, it seems important to adopt a common or consistent set of research paradigms for studying its effects. The present study shows how social and technological variables can be examined together efficiently to advance both social science understanding of group behavior and human factors of technology innovation.

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Appendix

Instructions

Introduction: We are studying decision making in groups. For this purpose we have created a decision making simulation. Everything about this problem is fictitious, but we want you to take things at face value.

You are a purchasing executive who selects new systems for the U.S. Aerospace Force. Your job is to direct a team of analysts, review their work, and then select systems to purchase. After you make an initial selection on your own, you will join a team of fellow executives to make a final selection jointly.

Three companies have submitted proposals for a new intelligence gathering system. The system and selection criteria are described on the next page. Your task is to study the system description, selection criteria, and the three proposal summaries and make an initial ranking. After this we will collect the summaries and ask you to complete a brief questionnaire. Then you will join your follow executives and prepare a group decision. This decision is a ranking of the three companies on the evaluation criteria.

You will have twenty minutes to read the system description, evaluation criteria, and the three proposal summaries. You will not be allowed to take the proposal summaries into the group meeting. So study the materials carefully.

Ranking the Proposals: There are 10 proposal evaluation criteria. Rank the proposals so that the one that meets the most criteria is ranked first. All criteria are equally important. In other words, if the system is a car, braking power is just as important as speed. Do not try to evaluate how well each criterion is met. It is either met or not met. The best system may not meet every criterion. Rank the proposed systems FIRST, SECOND, and THIRD using the 10 criteria and no others.

General System Description

The new system will be used to gather, process, and transmit information from behind enemy lines. This information, about the location and movements of enemy ground forces, will be used to plan tactical air strikes. The new system will have three parts: ground sensors, an air vehicle, and an on-board computer.

The ground sensors will be placed inside enemy territory. The sensors have passive sonar beacons that detect the movement of tanks and other military equipment. They will be placed secretly over an area of about 50 square miles in a random pattern. These ground sensors already exist.

An air vehicle with an on-board computer is now needed to complete the intelligence system. The air vehicle must fly over the sensor field with a low probability of being detected by enemy forces. It will have an advanced technology computer processor able to collect, process, and transmit the ground sensor data while in flight. The sensor data are transmitted to an Aerospace Battle Control Center for use in mission planning.

Evaluation Criteria: Ten criteria have been established for selecting the company that will build the new intelligence system.

Ideally, the Air Vehicle would:

1. Fit on a 2-ton capacity truck
2. Sweep the entire ground sensor field in 30 minutes or less
3. Be recovered and relaunched within 90 minutes

Ideally, the Computer Processor would:

4. Process data at 100 million instructional sets per second (MIPS)
5. Be no larger than 40 cubic inches
6. Be no heavier than 10 pounds
7. Average at least 1000 operating hours between failures

In addition, three business criteria will be evaluated. These are:

8. The air vehicle and computer cost $7 million or less
9. Past performance and experience of the company are positive
10. Current manufacturing capacity is adequate

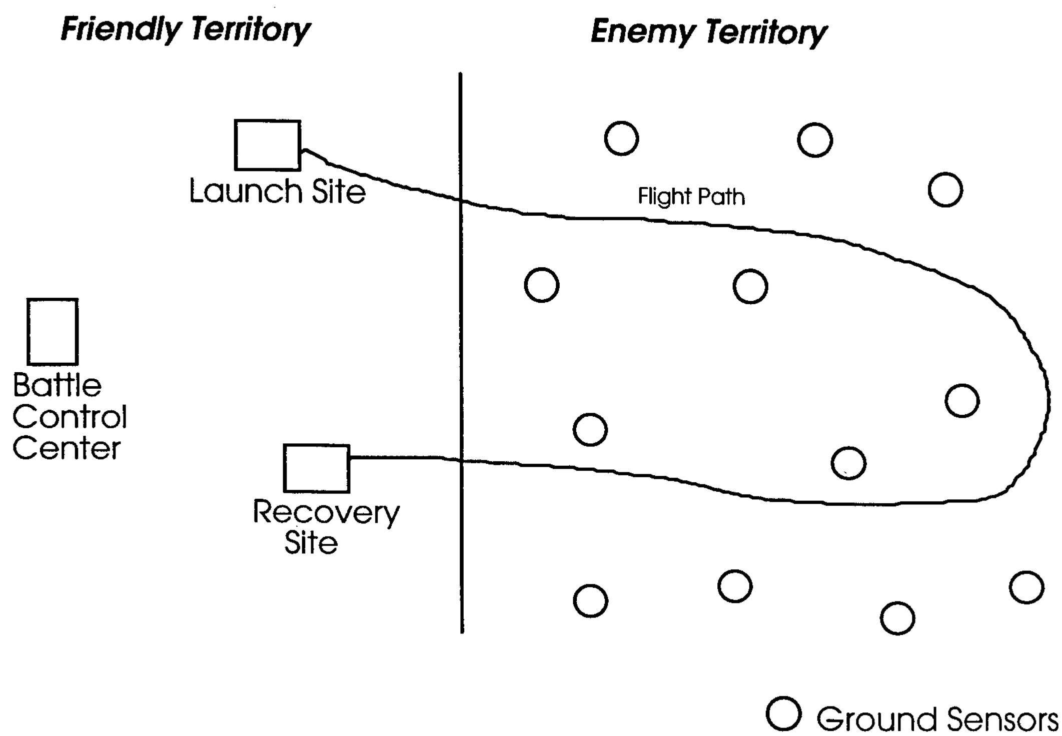
Proposals: Three companies have submitted proposals. These are:

A manned helicopter by Starlight Corporation

A radio-controlled airplane by Cape Industries

A modified cruise missile by Franklin Enterprises

Staff summaries of these proposals follow.


Friendly Territory
Enemy Territory
Launch Site
Flight Path
Battle
Control
Center
Recovery
Site
Ground Sensors

True Profile (Read by all Ss in control groups.)

Proposal of Franklin Enterprises
Staff Summary Sheet

Franklin will use unarmed cruise missiles modified to collect and transmit sensor data. Automatic navigation aids will guide the missile on a low-altitude flight path over the sensor field and return it to a predetermined location near its launch site. The missile will land by parachute. The computer processor has been clocked at 380 MIPS by the Defense Computer Testing Authority. The computer is packaged in a very small box that fits in a 28-cubic-inch space and weighs only 7 pounds. The computer is also highly reliable; on average, it operates for 1,500 hours before it fails.

By using existing cruise missiles taken from storage, Franklin can provide its system for $5,000,000 per unit. Low altitude flight helps the missile to avoid radar detection. However, the missile needs at least 40 minutes to sweep the entire sensor field. The cruise missile is easily handled by a two-person ground crew. The launch and recovery equipment, to be manufactured by Franklin, includes a hoist that allows the missile to be handled by one person if needed. However, it takes 110 minutes, on average, to recover and relaunch the missile.

Another drawback of the Franklin proposal is that the missile won't fit on an all-terrain, 2-ton capacity truck. The missile carrier and handling equipment require an 18-wheel tractor-trailer which cannot be driven over rough terrain.

Franklin is a small, employee-owned business located in Utah. Though started in Hidden Valley, where the computer laboratory is still located, the company has moved its headquarters to Salt Lake City. Franklin has no current manufacturing capacity for the launch and recovery equipment. (The cruise missiles themselves are already in storage and require only minor modification.) The company says it will be able to obtain financing to build a manufacturing facility if it wins the contract. The company currently employs about 250 persons. Our past experience with Franklin has been negative. They are often late in providing products.

True Profile (Read by all Ss in control groups.)

Proposal of Cape Industries
Staff Summary Sheet

Cape Industries proposes a radio-controlled airplane with folding wings powered by a single jet engine. Cape has more than 25 years experience building such aircraft drones, which are piloted from the ground. The crew operates the airplane from inside the 2-ton capacity truck using driver side and passenger side displays and controls. When the truck is moved, the displays and controls switch from "fly" to "drive" mode. This is an innovative concept since it allows the crew to remain safely and comfortably inside the truck most of the time.

The airplane can be recovered and relaunched in less than 60 minutes, even by an inexperienced crew. The Cape airplane is difficult to detect because of its small size. A drawback is that the airplane takes more than 80 minutes to sweep the entire ground sensor field. But all equipment, including the airplane, fits in a 2-ton capacity truck.

The computer processor is made by Paradox Micro Devices, Inc. It consistently processes data at 200 MIPS. It also has sophisticated packaging that allows it to fit in a 35 cubic-inch box. However, it weighs 11 pounds and the computer processor is unreliable; it fails every 400 hours on average.

Cape Industries has a modern airplane factory with adequate capacity at Cape May, New Jersey. The company headquarters are in Groton, Connecticut. Our experience with Cape on other contracts has been positive. But Cape products are also very expensive. The company proposes a cost of $8,000,000 per unit.

True Profile (Read by all Ss in control groups.)

Proposal of Starlight Corporation
Staff Summary Sheet

Starlight proposes a manned helicopter. It is powered by two jet engines. With these engines the helicopter can easily sweep the sensor area within 30 minutes. The computer processor will be subcontracted to Wonder Chips, Inc. of Carmel, California. Wonder's computer processor uses advanced 3-D wafer design. The Defense Computer Testing Authority has certified that this processor will exceed 200 MIPS. In addition, the processor has been tested in harsh environments and found to operate more than 1,500 hours on average without failure. The processor measures 20 cubic inches and weighs less than 8 pounds.

One drawback with the Starlight helicopter is that it takes three hours to recover and relaunch. In addition, the requirement for a human pilot increases personnel and training needs for the system. Another drawback is that the helicopter cannot fit on a 2-ton capacity truck. An 8-ton capacity truck is needed, and the helicopter must be disassembled for ground transportation. This greatly reduces its mobility. The Starlight helicopter will defeat detection by enemy radar because many "stealth" features have been included in its design.

Starlight is a Fortune 500 company with more than 35,000 employees. Its past performance on similar projects has been excellent. Starlight has built many successful helicopters for the Army and the civilian aviation market for over three decades. In addition, Starlight has recently built a factory in Houston, Texas. This factory is capable of producing an adequate number of helicopters per year. The proposed cost is $6,000,000 per unit.

(Notes: Italics added to these hidden profile write-ups show location of relevant information. Italics were not used in actual experiment. In addition, we did not show subject number or "hidden profile" on the sheets. Finally, the order of presentation for each subject was randomized. After pilot testing, we presented the information shown here as a connected narrative in a bulletized format and we elminated the distractor information to reduce cognitive load of the task.)

Hidden Profile
(Subject #1)
Proposal of Franklin Enterprises

Staff Summary Sheet

Franklin will use unarmed cruise missiles modified to collect and transmit sensor data. Automatic navigation aids will guide the missile on a low-altitude flight path over the sensor field and return it to a predetermined location near its launch site. The missile will land by parachute. The computer processor has been *clocked at 380 MIPS* by the Defense Computer Testing Authority. The computer is packaged in a very small box that *fits in a 28-cubic-inch space* and *weighs only 7 pounds*. The computer is also highly reliable; on average, it *operates for 1,500 hours before it fails*.

By using existing cruise missiles taken from storage, Franklin can provide its system for *$5,000,000 per unit.* Low altitude flight helps the missile to avoid radar detection. However, the missile *needs at least 40 minutes to sweep the entire sensor field.* The cruise missile is easily handled by a two-person ground crew. The launch and recovery equipment, to be manufactured by Franklin, includes a hoist that allows the missile to be handled by one person if needed.

Franklin is a small, employee-owned business located in Utah. Though started in Hidden Valley, where the computer laboratory is still located, the company has moved its headquarters to Salt Lake City. The company currently employs about 250 persons. Our *past experience with Franklin has been negative*. They are often late in providing products.

Hidden Profile
(Subject #1)
Proposal of Cape Industries

Staff Summary Sheet

Cape Industries proposes a radio-controlled airplane with folding wings powered by a single jet engine. Cape has more than 25 years experience building such aircraft drones, which are piloted from the ground. The crew operates the airplane from inside the *2-ton capacity truck* using driver side and passenger side displays and controls. When the truck is moved, the displays and controls switch from "fly" to "drive" mode. This is an innovative concept since it allows the crew to remain safely and comfortably inside the truck most of the time.

The airplane *can be recovered and relaunched in less than 60 minutes,* even by an inexperienced crew. The Cape airplane is difficult to detect because of its small size. All equipment, including the airplane, *fits in a 2-ton capacity truck.*

The computer processor is made by Paradox Micro Devices, Inc. It has sophisticated packaging that allows it to *fit in a 35 cubic-inch box.* However, it *weighs 11 pounds* and the computer processor is unreliable; it *fails every 400 hours* on average.

The company headquarters are in Groton, Connecticut. Our *experience with Cape on other contracts has been positive.* But Cape products are also very expensive. The company proposes a *cost of $8,000,000 per unit.*

Hidden Profile
(Subject #1)

Proposal of Starlight Corporation

Staff Summary Sheet

Starlight proposes a manned helicopter. It is powered by two jet engines. With these engines the helicopter can easily *sweep the sensor area within 30 minutes.* The computer processor will be subcontracted to Wonder Chips, Inc. of Carmel, California. Wonder's computer processor uses advanced 3-D wafer design.

One drawback with the Starlight helicopter is that *it takes three hours to recover and relaunch.* In addition, the requirement for a human pilot increases personnel and training needs for the system. Another drawback is that the helicopter *cannot fit on a 2-ton capacity truck.* An 8-ton capacity truck is needed, and the helicopter must be disassembled for ground transportation. This greatly reduces its mobility. The Starlight helicopter will defeat detection by enemy radar because many "stealth" features have been included in its design.

Starlight is a Fortune 500 company with more than 35,000 employees. It is a conglomerate with divisions producing a wide variety of products, ranging from armored personnel carriers to zenographic equipment. In addition, Starlight has recently built a new helicopter factory in Houston, Texas. *This factory is capable of producing an adequate number of helicopters per year.*

Hidden Proile

(Subject #2)

Proposal of Franklin Enterprises

Staff Summary Sheet

Franklin will use unarmed cruise missiles modified to collect and transmit sensor data. Automatic navigation aids will guide the missile on a low-altitude flight path over the sensor field and return it to a predetermined location near its launch site. The missile will land by parachute. The computer processor has been *clocked at 380 MIPS* by the Defense Computer Testing Authority. The computer is packaged in a very small box that *fits in a 28-cubic-inch space* and *weighs only 7 pounds*. The computer is also highly reliable; on average, it *operates for 1,500 hours before it fails*.

By using existing cruise missiles taken from storage, Franklin can provide its system for *$5,000,000 per unit*. Low altitude flight helps the missile to avoid radar detection. *It takes 110 minutes, on average, to recover and relaunch* the missile. The cruise missile is easily handled by a two-person ground crew. The launch and recovery equipment, to be manufactured by Franklin, includes a hoist that allows the missile to be handled by one person if needed.

Franklin is a small, employee-owned business located in Utah. Though started in Hidden Valley, where the computer laboratory is still located, the company has moved its headquarters to Salt Lake City. The company currently employs about 250 persons. Our *past experience with Franklin has been negative*. They are often late in providing products.

Hidden Profile

(Subject #2)

Proposal of Cape Industries

Staff Summary Sheet

Cape Industries proposes a radio-controlled airplane with folding wings powered by a single jet engine. Cape has more than 25 years experience building such aircraft drones, which are piloted from the ground. The crew operates the airplane from inside *the 2-ton capacity truck* using driver side and passenger side displays and controls. When the truck is moved, the displays and controls switch from "fly" to "drive" mode. This is an innovative concept since it allows the crew to remain safely and comfortably inside the truck most of the time.

The Cape airplane is difficult to detect because of its small size. All equipment, including the airplane, *fits in a 2-ton capacity truck*. A drawback is that the airplane *takes more than 80 minutes* to sweep the entire ground sensor field.

The computer processor is made by Paradox Micro Devices, Inc. It consistently *processes data at 200 MIPS*. But the computer processor is unreliable; it *fails every 400 hours* .on average.

Cape Industries has its company headquarters in Groton, Connecticut. Our *experience with Cape on other contracts has been positive*. Cape Industries *has a modern airplane factory with adequate capacity* at Cape May, New Jersey. But Cape products are also very expensive. The company proposes *a cost of $8,000,000 per unit*.

Hidden Profile

(Subject #2)

Proposal of Starlight Incorporated

Staff Summary Sheet

Starlight proposes a manned helicopter. It is powered by two jet engines. The computer processor will be subcontracted to Wonder Chips, Inc. of Carmel, California. Wonder's computer processor uses advanced 3-D wafer design. The processor *weighs less than 8 pounds*, and measures *20 cubic inches*.

One drawback with the Starlight helicopter is that it *takes three hours to recover and relaunch*. In addition, the requirement for a human pilot increases personnel and training needs for the system. Another drawback is that the helicopter *cannot fit on a 2-ton capacity truck*. An 8-ton capacity truck is needed, and the helicopter must be disassembled for ground transportation. This greatly reduces its mobility. The Starlight helicopter will defeat detection by enemy radar because many "stealth" features have been included in its design.

Starlight is a Fortune 500 company with more than 35,000 employees. Starlight has its headquarters in Houston, Texas.

Hidden Profile
(Subject #3)

Proposal of Franklin Enterprises

Staff Summary Sheet

Franklin will use unarmed cruise missiles modified to collect and transmit sensor data. Automatic navigation aids will guide the missile on a low-altitude flight path over the sensor field and return it to a predetermined location near its launch site. The missile will land by parachute. The computer processor has been *clocked at 380 MIPS* by the Defense Computer Testing Authority. The computer is packaged in a very small box that *fits in a 28-cubic-inch space* and *weighs only 7 pounds*. The computer is also highly reliable; on average, it *operates for 1,500 hours before it fails*.

By using existing cruise missiles taken from storage, Franklin *can provide its system for $5,000,000 per unit*. Low altitude flight helps the missile to avoid radar detection. The launch and recovery equipment, to be manufactured by Franklin, includes a hoist that allows the missile to be handled by one person if needed. However, the Frankin missile *won't fit on an all-terrain, 2-ton capacity truck*. The missile carrier and handling equipment require an 18-wheel tractor-trailer which cannot be driven over rough terrain.

Franklin is a small, employee-owned business located in Utah. Though started in Hidden Valley, where the computer laboratory is still located, the company has moved its headquarters to Salt Lake City. The company currently employs about 250 persons. Our *past experience with Franklin has been negative*. They are often late in providing products.

Hidden Profile

(Subject #3)

Proposal of Cape Industries

Staff Summary Sheet

Cape Industries proposes a radio-controlled airplane with folding wings powered by a single jet engine. Cape has more than 25 years experience building such radio-controlled aircraft drones, which are piloted from the ground. Their radios use a proprietary super-heterodyne system which has a range of over 100 miles, but whose signal is very difficult to detect without a special receiver.

The airplane can be *recovered and relaunched in less than 60 minutes,* even by an inexperienced crew. The Cape airplane is difficult to detect because of its small size. A drawback is that the airplane *takes more than 80 minutes to sweep the entire ground sensor field.*

The computer processor is made by Paradox Micro Devices, Inc. It consistently *processes data at 200 MIPS*. But it *weighs 11 pounds.*

Cape Industries has a modern *airplane factory with adequate capacity* at Cape May, New Jersey. The company headquarters are in Groton, Connecticut. Our *experience with Cape on other contracts has been positive*. But Cape products are also very expensive. The company proposes a *cost of $8,000,000 per unit.*

Hidden Profile
(Subject #3)

Proposal of Starlight Incorporated

Staff Summary Sheet

Starlight proposes a manned helicopter. It is powered by two jet engines. The computer processor will be subcontracted to Wonder Chips, Inc. of Carmel, California. Wonder's computer processor uses advanced 3-D wafer design. The Defense Computer Testing Authority has certified that this processor will exceed *200 MIPS*. In addition, the processor has been tested in harsh environments and found to *operate for more than 1,500 hours on average without failure.*

One drawback with the Starlight helicopter is that it takes three hours to recover and relaunch. In addition, the requirement for a human pilot increases personnel and training needs for the system. Another drawback is that the helicopter *cannot fit on a 2-ton capacity truck.* An 8-ton capacity truck is needed, and the helicopter must be disassembled for ground transportation. This greatly reduces its mobility. The Starlight helicopter will defeat detection by enemy radar because many "stealth" features have been included in its design.

Starlight is a Fortune 500 company with more than 35,000 employees. Starlight has its headquarters in Houston, Texas.

Hidden Profile
(Subject #4)
Proposal of Franklin Enterprises

Staff Summary Sheet

Franklin will use unarmed cruise missiles modified to collect and transmit sensor data. Automatic navigation aids will guide the missile on a low-altitude flight path over the sensor field and return it to a predetermined location near its launch site. The missile will land by parachute. The computer processor has been clocked at *380 MIPS* by the Defense Computer Testing Authority. The computer is packaged in a very small box that *fits in a 28-cubic-inch space* and *weighs only 7 pounds*. The computer is also highly reliable; on average, it *operates for 1,500 hours before it fails*.

By using existing cruise missiles taken from storage, Franklin can provide its system for *$5,000,000 per unit*. Low altitude flight helps the missile to avoid radar detection. The launch and recovery equipment, to be manufactured by Franklin, includes a hoist that allows the missile to be handled by one person if needed.

Franklin is a small, employee-owned business located in Utah. Though started in Hidden Valley, where the computer laboratory is still located, the company has moved its headquarters to Salt Lake City. *Franklin currently has no manufacturing capacity* for the launch and recovery equipment. The cruise missiles themselves are already in storage and require only minor modifications. The company says it will be able to obtain financing to build a manufacturing facility if it wins the contract. The company currently employs about 250 persons. Our *past experience with Franklin has been negative*. They are often late in providing products.

Hidden Profiles
(Subject #4)

Proposal of Starlight Incorporated

<u>Staff Summary Sheet</u>

Starlight proposes a manned helicopter. It is powered by two jet engines. The computer processor will be subcontracted to Wonder Chips, Inc. of Carmel, California. Wonder's computer processor uses advanced 3-D wafer design.

One drawback with the Starlight helicopter is that it *takes three hours to recover and relaunch.* In addition, the requirement for a human pilot increases personnel and training needs for the system. Another drawback is that the helicopter *cannot fit on a 2-ton capacity truck..* An 8-ton capacity truck is needed, and the helicopter must be disassembled for ground transportation. This greatly reduces its mobility. The Starlight helicopter will defeat detection by enemy radar because many "stealth" features have been included in its design.

Starlight is a Fortune 500 company with more than 35,000 employees. Its *past performance on similar projects has been excellent.* Starlight has designed many other successful systems for the Army and the civilian aviation market for over three decades. Starlight has its headquarters in Houston, Texas. The proposed *cost is $6,000,000 per unit.*

Hidden Profiles
(Subject #4)
Proposal of Cape Industries

Staff Summary Sheet

Cape Industries proposes a radio-controlled airplane with folding wings powered by a single jet engine. These radio-controlled aircraft drones are piloted from the ground. The crew operates the airplane from inside the 2-ton capacity truck using driver side and passenger side displays and controls. When the truck is moved, the displays and controls switch from "fly" to "drive" mode. This is an innovative concept since it allows the crew to remain safely and comfortably inside the truck most of the time.

The airplane *can be recovered and relaunched in less than 60 minutes,* even by an inexperienced crew. The Cape airplane is difficult to detect because of its small size. All equipment, including the airplane, *fits in a 2-ton capacity truck..* A drawback is that the airplane *takes more than 80 minutes to sweep the entire ground sensor field.*

The computer processor is made by Paradox Micro Devices, Inc. It consistently *processes data at 200 MIPS.* It has sophisticated packaging that allows it to *fit in a 35 cubic-inch box.* But it *weighs 11 pounds* and is unreliable; it *fails every 400 hours, on average.*

The company headquarters are in Groton, Connecticut.